DOCUMENT RESUME

ED 158 722 IR 006 176

AUTHOR Schneider, Edward W.
TITLE Applications of Videodisc Technology to Individualized Instruction.
INSTITUTION Brigham Young Univ., Provo, Utah. Div. of Instructional Research, Development, and Evaluation.
REPORT NO ICUE-TR-15
PUB DATE Sep 75
NOTE 22p.; Paper presented at the National Science Foundation Conference for Ten Year Forecast for Computers and Communications (Warrenton, Virginia, September 16-18, 1975); For related documents, see IR 006 172, 175

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS Bibliographies; *Computer Assisted Instruction; Display Systems; *Individualized Instruction; Instructional Media
IDENTIFIERS *Videodisc Recordings

ABSTRACT

Several general considerations and characteristics are described and illustrated for the application of videodisc technology to individualized instruction: (1) a prototype of a videodisc unit, (2) digital read-only memory, (3) cost economics, (4) educational uses, (5) development versus delivery systems, and (6) prerequisites for successful videodisc terminals. A bibliography of descriptive material on videodisc technology is included. (CMV)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

10+p L

ED158722

INSTITUTE FOR COMPUTER USES IN EDUCATION

APPLICATIONS OF VIDEODISC TECHNOLOGY TO INDIVIDUALIZED INSTRUCTION

Edward W. Schneider, Ph.D.

ICUE Technical Report No. 15

September, 1975

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Harold H. Hendricks

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

Presented at the National Science Foundation
Education Directorate, Conference for:

Ten-Year Forecast for Computers
and Communications

Implications for Education

September 16-18, 1975
Airlie House
Warrenton, Virginia

Coordinator: Human Resources Research Organization

DIVISION OF INSTRUCTIONAL RESEARCH, DEVELOPMENT
AND EVALUATION
Brigham Young University
Provo, Utah

IR006176

APPLICATIONS OF VIDEODISC TECHNOLOGY TO INDIVIDUALIZED INSTRUCTION

To begin, let me show you a few pictures of a prototype of a videodisc unit. I will describe only the Philips/MCA unit, (illus. 1) but other devices are also being developed by Zenith Radio, Sony, and RCA. Basically, the unit consists of a turntable (illus. 2) scanned by a traveling arm. A microscope objective mounted on the arm focuses the light from a low-power laser on the reflective surface of the videodiscs. A string of microscopic pits of varying lengths have been pressed into the plastic surface of the disc (illus. 3) If the laser light shines on a portion of the disc where there is no pit, the light is reflected back along the same optical path and is detected by a photoreceptor. If the light shines into a pit, it is diffused, and very little light returns along the original path. The transition points from pit to no pit, and vice versa, define the zero crossings of the original frequency-modulated video signal. Using the zero crossing information, the original composite video waveform is reconstructed, and is used to modulate an appropriate RF carrier so that the signal may be input to the antenna terminals of a conventional television receiver.

Each disc typically contains thirty minutes of video material; the technology for 60-minute discs already exists. With each revolution of the disc, one frame of video is displayed; the track width for each frame, pits and guard-bands included, is approximately 2 microns wide. In order to keep eccentricities in the replicated disc

and other such perturbations from making the optics jump the track, a servo-system controls a galvanometer mirror, which keeps the laser beam centered on the desired track. By stepping the mirror motor, it is possible to access any one of several adjacent tracks; access to more distant tracks requires movement of the microscope objective. This is accomplished with a conventional electric motor and lead-screw arrangement. If the galvanometer mirror is stepped backward one track during each retrace cycle, the same frame is played over and over again, providing a "freeze frame" capability. If every track is played twice, a slow-motion effect is obtained. All kinds of tinkering are possible, because each frame has a digital address which is read by the player; in fact, during the fast forward and fast reverse operations the address is superimposed on a small portion of the screen. If we add a small microprocessor and give it access to the frame number and also let it control the track selection process. . . but I am getting ahead of my story; I have just barely described the machine and already I am modifying it. To summarize its hardware advantages, we can say that videodisc is free of the wear factors characteristic of videotape players, provides very high density of information storage, and, compared with the prior art, is delightfully easy on the pocketbook; a player will cost about $500.00, and discs will cost about $2.00 to $5.00 apiece, depending upon program material.

Videodiscs as Digital Read-only Memory.

For those of you whose pulse is not quickened at the thought of Hollywood movie companies retailing old Doris Day motion pictures

without having to wholesale them to television networks, let me suggest videodiscs may be another instance of a good thing happening, for what is probably the wrong reason. Rest assured that, down deep, optical videodiscs are inherently digital devices. We can think of them as moving head disc units with demountable platters that are always write-protected. Each platter has 54,000 tracks that store, depending upon formatting conventions, a total of between twelve and seventeen gigabits per disc. To obtain these densities, a read-rate of approximately eleven megabits per second is required. This will be a problem for some computers, because they will have a hard time keeping up. Unfortunately, the average track access time is 4.5 seconds, but that isn't really so bad whan you consider that a conventional twenty-surface disc unit similar to the IBM 2314 would require an average access time of 4 seconds, if its disc pack were made large enough to hold the same amount of information as a videodisc. I have been assured that the access time can be decreased by a factor of two or three, simply by beefing up the videodisc's lead-screw motor. Lastly, the storage costs are approximately 0.12 microdollars per bit, if you include the cost of the drive, and make only one copy. The cost of just the disc varies between 25 nanodollars/bit for one copy to 35 picodollars/bit for 1,000 copies.

Economics of Videodiscs.

There are several cost comparisons that I would like to share with you. These data were assembled with the help of Eddy Zwaneveld of BYU's Motion Picture Studio. The first table shows the relative

costs of reproducing equipment. With each video system, I have included the costs of a color monitor. With each motion picture system I have included the cost of a screen. As you can see, videodisc is the cheapest video apparatus, but it is not as cheap as a film projector.

The second cost comparison (Table 2) is more telling. Here, we have compared the per-copy cost for 1, 10, 100, and 1,000 copies of a 30-minute program. We see that videodisc is not the cheapest for various small numbers of copies but that its cost drops quite rapidly with any real volume. Because of its freeze-frame capabilities, it is reasonable to compare videodisc with still-frame visual media (Table 3). We see that in quantity, nothing beats out the videodisc. To combine these cost estimates, let us suppose that we have a cozy education network of one hundred elementary schools, in a two hundred square mile area. Each school has 550 pupils. We provide each school with the capability of viewing six different programs simultaneously, and we now provide each school with a library (or in the case of broadcast systems, a catalog) of 200 30-minute programs. Each program is shown an average of four times during each school year. In the case of centrally-programmed systems, approximately 35 channels would be required, and each program would be played an average of 300 times per year. If the initial outlay is amortized over five years, the yearly costs for the competing delivery systems are shown in Table 4. The recurring costs after the initial five-year period arise from the need to replace program copies that wear out, and maintenance requirements. We conclude that this network can save $23,000.00 a year by

giving each school its own library of videodiscs, instead of running a conventional film distribution system. If the schools contemplate a closed-circuit TV system, they can reduce the average annual cost by 42% - if they install videodiscs instead of videotapes.

Educational Uses of Videodiscs.

Judging by the cost figures shown above, it will only be a matter of time until videodiscs completely replace conventional motion pictures in educational institutions. This is especially true if projection television displays become just a bit cheaper.

Another and more innovative possibility is the use of videodiscs to replace the monochrome postcard reproductions that fine-arts students buy, and the sets of microscope slides that are inflicted on students of medicine and life sciences. Videodiscs will be used as image banks for both still and motion sequences. For example, it will be possible when studying dynamic systems such as the growth of an embryo or the oscillations of a mechanical system, to record different views of the same process on adjacent videodisc tracks, and to switch from one viewpoint to another by pressing buttons on an external keyboard. This capability would allow the student to manipulate, at least in a crude way, the material under study.

Videodiscs would also replace the ubiquitous slide/tape shows. In order to provide audio, the videodisc would work in a normal "motion picture" manner when audio was required. When audio is not required, a still-frame or a sequence of still-frames could be shown. The still-frames would contain study questions, discussion points, or summaries,

and the video player would continue to show them until it received a command to go on.

More sophisticated interactive applications would require the addition of a more elaborate keyboard and a microprocessor to control the videodisc player. We are in the initial design phases of specifying not one, but a family of interactive machines that are capable of varying degrees of processing a student's answer. The simplest machine would accept multiple choice answers (A, B, C, D) and would branch to a specific frame, depending upon which answer was selected. With the addition of a small amount of memory, such machines would work well in adaptive testing applications, where the selection of the next test item depends upon the response history of the student up to that point. A little more memory, say on the order of two to four thousand words, and a simple character generator to display about 50 characters of student input, would allow the videodisc system to support a slightly modified version of the learner-controlled computer-assisted instruction that is now being evaluated on the TICCIT System. We will be able to get by with a very small memory because we will appropriate some of the video frames to store digital instructions and data for the microprocessor. Whenever a digital frame is encountered, it will automatically load some data into specified regions of the microprocessor's memory. To show more clearly how this will work, let me explain the architecture of TICCIT courseware and its relation to student control of instruction.

In the TICCIT System, a course of instruction is sub-divided (Figure 1) into units, and the units are further sub-divided into

lessons, and the lessons are yet further divided into segments. Each segment, each lesson, and each unit has a set of behavioral objectives that define its goal and content. In addition to its objective, each segment has four principal components: statements of the rule or generality to be learned, examples of the rule being applied, practice items for the students to apply the rule, and helps, for when the students don't understand why things are as they are. Each of these functions is represented by a pushbutton on the TICCIT keyboard (Figure 2). In addition, there are buttons to modulate the difficulty of examples and practice items, and the conciseness of generality statements. This system is currently implemented using two NOVA 800 minicomputers to service up to 128 student terminals. When implemented with videodiscs, the terminals will become stand-alone devices. Each terminal (Figure 3) will consist of a TV monitor, a videodisc, a keyboard, and a microprocessor. When the students press "Rule" the microprocessor will control the videodisc player, and "Show" the frame whose frame address was stored in a certain location in the microprocessor's memory. The first page of this rule file would load digital data, defining the parameters of the file. Because all of the files in any one segment will be near each other on the disc, the student will not have to wait very long for the microprocessor to move the read arm of the player. Preliminary calculations indicate that a two-semester precalculus mathematics sequence which presently requires an entire 20-surface moving-head disc drive, will fit comfortably on two 12-inch videodiscs. We estimate that a complete hardware system to deliver this kind of computer-assisted instruction would cost approximately $1,800.00

per terminal. With the usual tack-ons for sales and service and for return on investment, the monthly rental charge to a student would be approximately $80.00. If three or four college students got together, they could easily afford to have their own terminal, and when they were tired of studying it could play "Airport" or "Ben Hur." as well as picking up the "Johnny Carson Show." In order to keep the student's instructor and the University's registrar informed of his progress in the course, the individual lessons could be stamped out on much smaller five-minute videodiscs, that would have a magnetic band in the otherwise unused center. The student's identification number and the results of the test administered at the end of the lesson would be recorded on this band. The student would return the completed lesson disc to the school library, where the magnetic band would be read, the information would be fed to a central recordkeeping computer, and the band would be erased for use by the next student. The computer would analyze test results, and compare them with previous test results. It would then prepare a summary of the student's performance with comments and recommendations that would be typed out at a remote printer in the library. The student files would also be analyzed by the student's instructor to determine both individual and group performance on the learning materials. This same technique would also work very well for a correspondence school, because videodiscs are small, light, and easy to mail.

Development versus Delivery Systems.

When used in this interactive fashion, videodiscs would require a clear distinction between the delivery system and the development

system. This distinction has not been necessary in earlier CAI systems, because the instructional content was always stored in a modifiable media, usually magnetic tape or disc. When instructional content is pressed rapidly and firmly into soft plastic, it is no longer possible to correct misspelled words, or to fix misleading feedback messages. A completely separate system that uses easily modifiable storage must be used to develop, evaluate and revise instructional content. This development system will, in all probability, resemble existing CAI systems rather closely, with the addition of hardware to produce and edit the videotape master that will be used to press the videodiscs.

Prerequisites for Successful Videodisc Terminals.

According to our contacts at MCA, videodiscs will be introduced on the commercial market in the last quarter of 1976. Implementing the kinds of systems that I have been talking about will not be a matter of simple waiting for the hardware. The major feasibility questions do not revolve around the videodisc technology, but around a still-infant instructional technology. To be really cost effective, videodiscs must be stamped in reasonable numbers, and therefore, a reasonable number of schools and students must agree to use them. This acceptance will not occur unless the material stamped on the disc really works, and works well. And it's not likely to work well unless it was developed and tested by people who had a pretty good idea of how to do the job right the first time. Unfortunately, instructional developers of such caliber are very few in number. Most CAI courses have been developed as if they were to be given as class lectures, and as a result they

haven't turned out to be much of an improvement over the class lectures that they were designed to replace. Until we have justifiable confidence in our instructional development procedures, we would do well to leave videodisc programming in the hands of the entertainment industry.

Summary.

Videodiscs will set new standards for inexpensive large-scale media distribution. They can do a lot more than provide home reruns of TV reruns. Educational use of videodiscs for the presentation of conventional linear motion pictures will probably catch on like wildfire. Non-linear, interactive applications will make a real contribution to the quality of education, but not until instructional development becomes a matter of production, instead of experimentation.

Illustration 1. Prototype of Philips/MCA videodisc player unit.

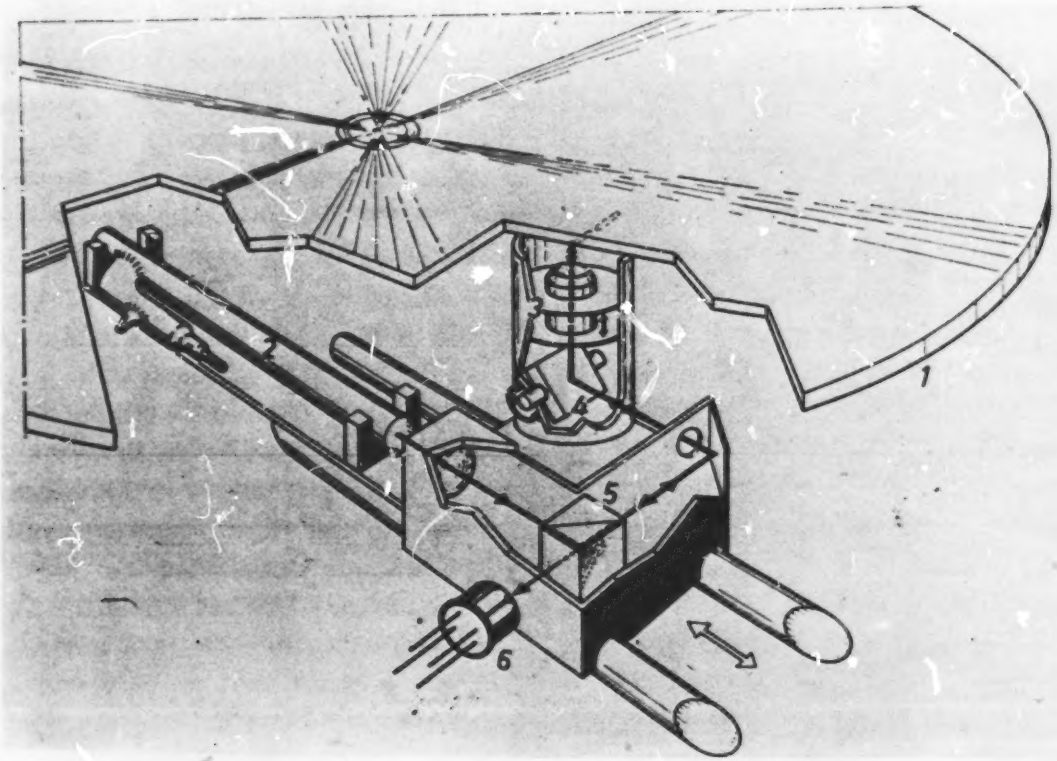


Illustration 2. Cut-away view of videodisc player mechanism. The disc (1) is scanned from below by a He-Ne laser (2). The objective lens (3) is focused dynamically by a small linear induction motor. A pivoting mirror (4) keeps the laser beam centered on the track. Incident and reflected light are separated by a prism (5). The amount of reflected light is measured by a photodetector (6). (From Philips tach. Rev.33, No.7.)

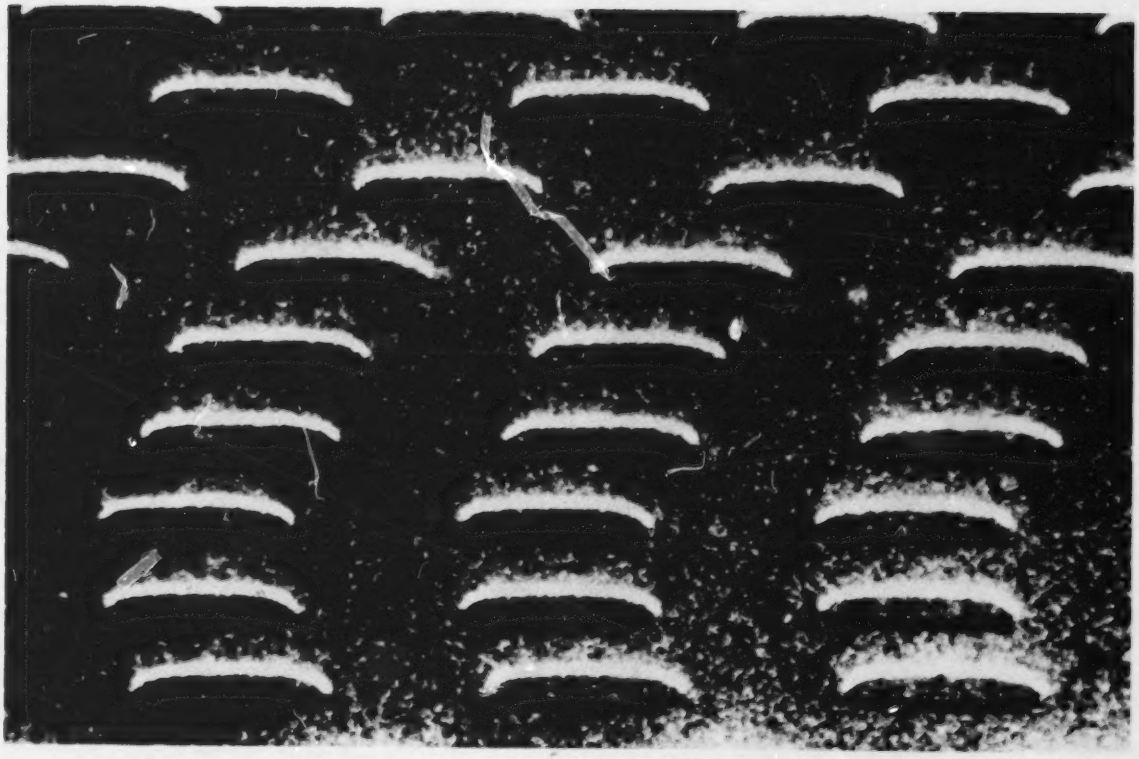


Illustration 3. Surface of videodisc, as seen with electron microscope. Pits are 4 - 6 μm. long, 0.7 μm. wide, and 0.1 μm. deep. Distance between adjacent tracks is 2 μm.

Table 1

Videodisc: reproduction equipment cost comparisons

Cost of AV reproduction equipment

1.	8 mm video player and monitor	$1.592.00
2.	3/4" videotape cassette player and monitor	1,500.00
3.	Optical videodisc player and monitor	900.00
4.	16 mm projector and screen	825.00
5.	8 mm projector and screen	554.00

Table 2

Per copy costs, one-half hour motion visual program

Medium	Quantity			
	1	10	100	1,000
16 mm film	417.00	108.00	84.52	66.17
8 mm film	285.00	66.00	52.00	44.76
3/4" video cassette	70.00	31.00	21.25	18.50
Videodisc	450.00	46.00	3.01	.63

Table 3

Per frame costs, in dollars, for still visuals (54,000 frames per set)

Medium	Quantity 1	10	100	1,000
35 mm color slides	0.25	0.20	0.15	0.09
35 mm color film strips	0.122	0.02	0.0085	0.0085
Microfiche, color	0.15	0.022	0.0083	0.0083
Microfilm, monochrome	0.10	0.017	0.0076	0.0076
Videodisc	0.0083	0.0009	0.00006	0.00001

Table 4

Annual costs (in thousands of dollars) for an education network (group viewing)

Medium	Year 1-5	6-10	Total - 10 year
Local Libraries			
3/4" videotape	314.	48.	1,570.
16 mm film	437.4	39.	2,382.
Videodisc	168.	48.	1,080.
Networks			
CCTV 3/4" videotape	310.36	116.2	2,383.
CCTV (videodiscs)	247.8	96.	1,239.
16 mm film Lending Library	182.36	79.6	1,310.

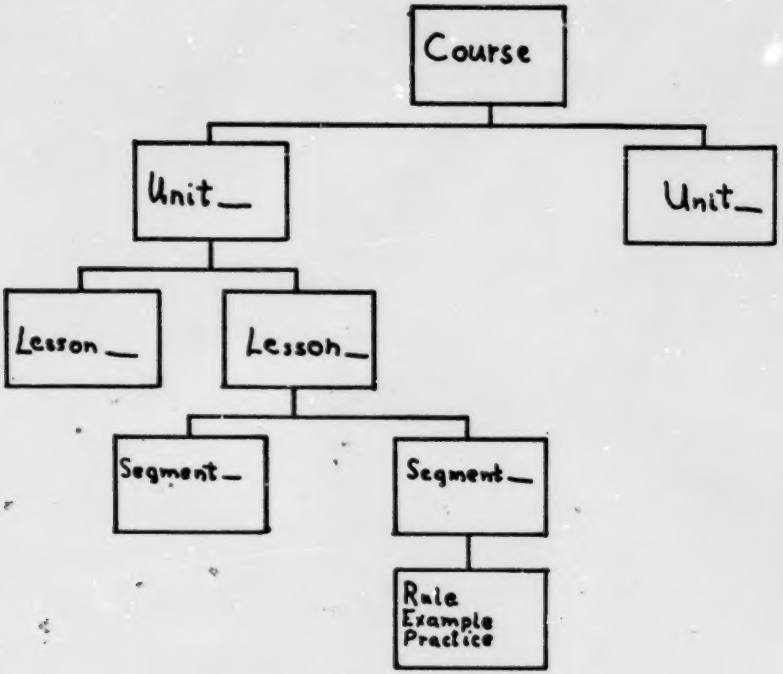


Figure 1. General structure of TICCIT courseware.

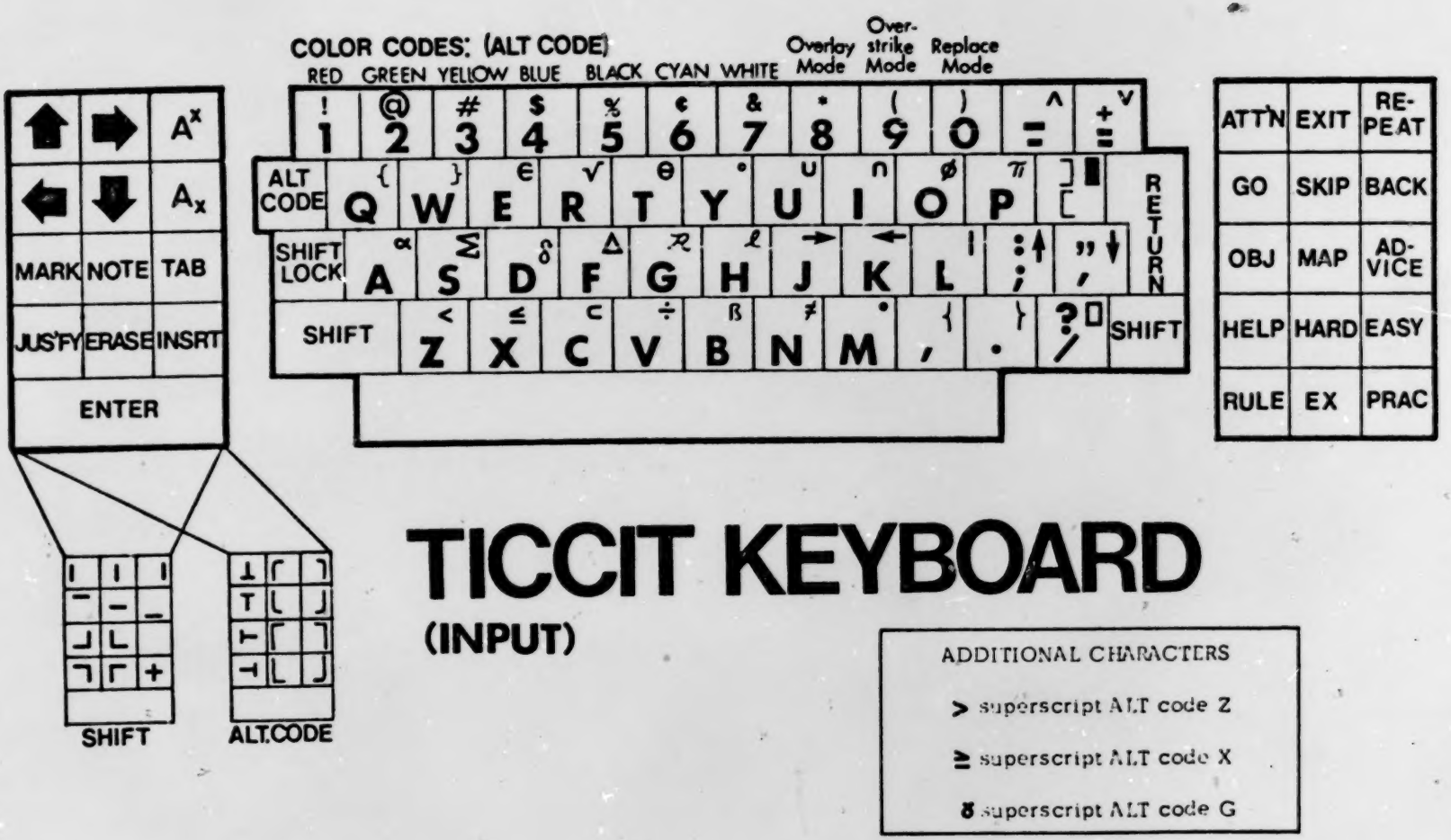
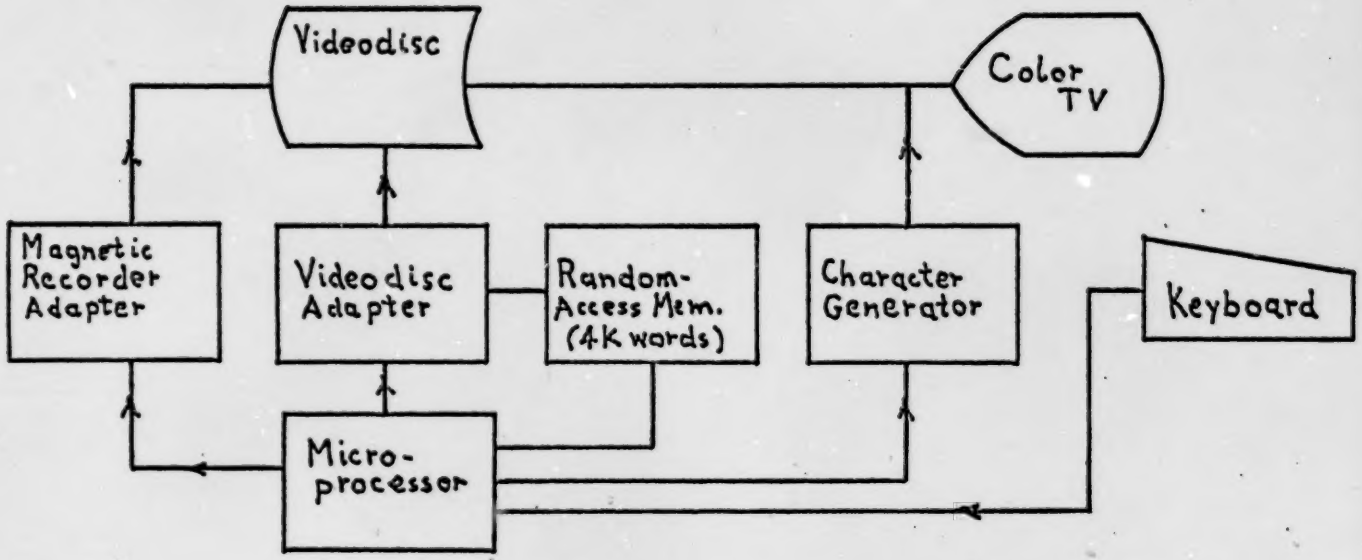


Figure 2. Keyboard layout for TICCIT CAI system.



Block Diagram of an Interactive Videodisc Terminal

Figure 3. Block diagram of an interactive videodisc terminal.

Videodisc Bibliography

Anonymous. Inexpensive TV cartridges may come from digital recordings. Product Engineering, Sept. 1974, p. 13.

Anonymous. MCA Disco-Vision. Informational Booklet. MCA Disco-Vision, Inc. Universal City, California.

Bennion, J.L. Possible applications of optical videodiscs to individualized instruction. Technical Report #10, Institute for Computer Uses in Education, Brigham Young University. Feb. 1974.

Bennion, J.L., Schneider, E.W. Interactive video-disc systems for education. Presentation at SMPTE regional conference, Provo, Utah, August 23, 1975.

Bounhuis, G. & Burgstede, P. The optical scanning system of the Philips "ULP" record player. Philip's Technical Review, 33, 7: 1973. pp. 186-189.

Broadbent, Kent D. A review of the MCA Disco-Vision system. Journal of the SMPTE, 83, July, 1974. pp. 554-559.

Compaan, K & Kramer, P. The Philips VLP system. Philips Technical Review, 33, 7, 1973. pp. 178-180.

Hrbek, G.W. An experimental optical videodisc playback system. Journal of the SMPTE, vol. 83, July 1974. pp. 580-582.

Janssen, P.J.M. & Day, P.E. Control mechanisms in the Philip's "VLP" record player. Philips Technical Review, 33, 7, 1973.pp. 190-193.

Jerome, J.A. & Kaczorowshi, E.M. Film-based videodisc system. Journal of the SMPTE, vol. 83, July 1974. pp. 560-563.

Pfannkuch , R. Characteristics of the Videodisc systems. Journal of the SMPTE, vol. 83, July, 1974. pp. 560-586.

Van der Bussche, W. et. al. Signal processing in the Philips "VLP" system. Philips Technical Review, 33, 7, 1973. pp. 181-185.

Winslow, K. A videodisc in your future. Educational and Industrial T.V. May, 1975. pp. 21-22.

Zwaneveld, E.H.A.E. An audiovisual producer/user's view of videodisc technology. Journal of the SMPTE, vol. 83, July 1974, PP. 593-584.